SEMESTER 5

HIGH SPEED AERODYNAMICS

Course Code	PCAOT501	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Fluid Mechanics, Low Speed Aerodynamics	Course Type	Theory

Course Objectives:

1. To introduce the concept of compressible flow.
2. To make the student understand the theory behind the formation of shocks and expansion fans in supersonic flows.
3. To introduce the methodology of measurements in supersonic flows and the effect of heat transfer and friction through constant area duct.

SYLLABUS

KTU SPECIAL

Module No.	Syllabus Description	Contact Hours
1	**INTRODUCTION TO COMPRESSIBLE FLOW AND NORMAL SHOCK**: Continuity, Momentum and energy equations for steady one dimensional flow, Concepts of stagnation condition, Velocity of sound, Adiabatic steady state flow equations, Flow through convergent- divergent passage, Performance under various back pressures (Numerical problem) , Mach cone, Mach angle, Normal shock relations(Numerical problem), Prandtl's relation, Hugoniot equation ,Rayleigh Supersonic Pitot tube equation, Moving normal shock waves. (Simple numerical examples)	13
2	**OBLIQUE SHOCK AND EXPANSIONS WAVES**: Oblique shock relation (Numerical problem), Shock Polar, Reflection and intersection of oblique shocks, Introduction to slip line compression corner effect, Expansion waves, Prandtl-Meyer expansion, Maximum turning angle (Numerical problem). Fanno flow and Rayleigh flow, Mass addition to the flow. (Numerical problem).	11
3	**DIFFERENTIAL EQUATIONS OF MOTION FOR STEADY COMPRESSIBLE FLOWS**: Small perturbation potential theory, Method of characteristics, solutions for supersonic flows, Prandtl-Glauert rule - affine transformation relations for subsonic flows, Linearised two-	10

	dimensional supersonic flow theory - Lift, drag, pitching moment and centre of pressure of supersonic profiles. (Numerical problem)	
4	**TRANSONIC FLOW OVER WING AND BOUNDARY LAYER EFFECTS IN SUPERSONIC FLOW:** Critical Mach number, drag divergence, Mach number, Shock Stall, Supersonic aerofoil and wings, Effect of thickness, camber and aspect ratio of wings, Supercritical Aerofoil Sections, Transonic area rule, Swept wing, Aerodynamic heating, Design considerations of supersonic airplane. Introduction to hypersonic aerodynamics.	**10**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE):

KTU SPECIAL

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks (8x3 =24 marks)	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 subdivisions. (4x9 = 36 marks)	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic theorems in compressible fluid dynamics.	**K2**
CO2	Apply the concepts of shock waves and compressible flow through variable area passages.	**K3**
CO3	Apply the concepts of Oblique shock and expansion waves and simple flows and able to solve complex problems	**K3**
CO4	Apply the airfoil wing and cone section presence in supersonic flow.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**	**2**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO2	**3**	**3**	**2**	**2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO3	**3**	**3**	**2**	**3**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO4	**3**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**

KTU SPECIAL

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Aerodynamics	John D Anderson	Mc Graw Hill Education	6th edition & 2016
2	Gas Dynamics	Ethirajan Rathakrishnan	PHI Learning Private limited	6th edition and 2018
3	Gas Tables	Rathakrishnan E	Orient Blackswan Private Limited - New Delhi	2013
4	Gas Tables for Compressible Flow Calculations	S M Yahya	New Age International Publishing	2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Compressible Flow	Anderson, J. D	Mc Graw Hill Education	4th edition & 2003
2	Compressible Fluid Flow	Oosthuizen,P.H., &Carscallen,W.E	McGraw- Hill & Co	1997
3	Dynamics and Thermodynamics of Compressible Fluid Flow	Shapiro, A. H	Shapiro, A. H	1982

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
Module – I to III	https://youtube.com/playlist?list=PLbMVogVj5nJRm6ODNAemYPS7E62_hPiqH&si=hd3SiAIEnFpcOl_A
Module IV	https://youtu.be/7VzLwVi5lW0?si=meQRQlI1ElCdV9VI

KTU SPECIAL